



# Multilayer Anti-Reflective Coating Development for PMMA Fresnel Lenses

Don Patterson, Keith Jamison, and Byron Zollars

Mirror Technology SBIR/STTR Workshop

Albuquerque, NM

June 17, 2009

# Radiation Hard Multilayer Optical Coatings

SBIR Phase II Contract

NNX09CB36C

Nanohmics, Inc.

# Space ready multi-layer optical coatings

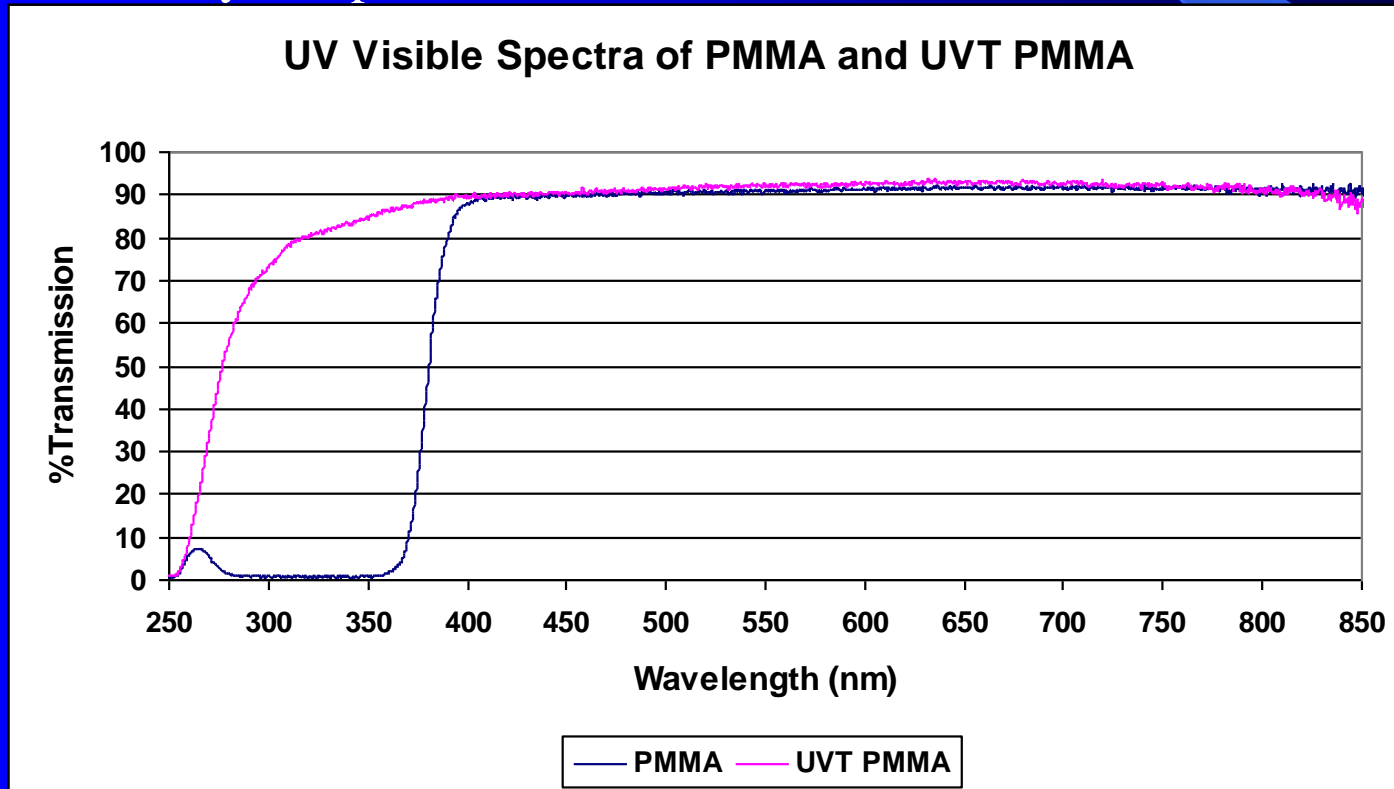
**Problem:** New optical coatings need to be developed for next generation light weight space base optics for use in programs such as NASA's EUSO observatory

**Phase II Goal:** Develop a robust anti-reflective coating that can be applied to PMMA Fresnel lenses

**Nanohmics' Approach:** Multi-layer amorphous nitrides / oxides as optical coating

# Why PMMA?

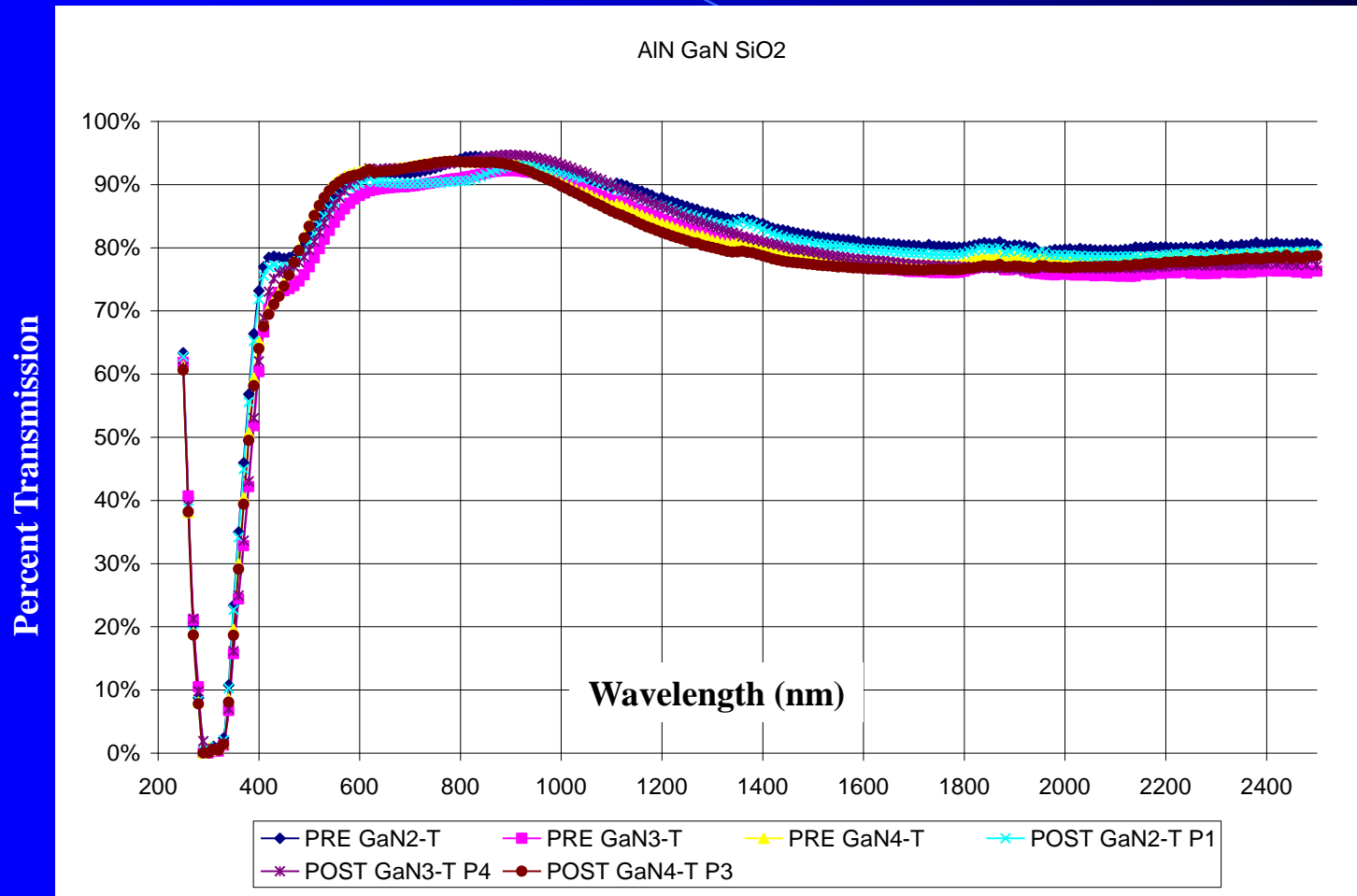
- Light weight
- UV Resistant
- UV Transparent
- Relatively inexpensive



# Advantages of Amorphous Oxides and Nitrides

- Proven radiation resistance to darkening
- Can be used to design anti-reflection, reflective, and band pass coatings
- Deposit on room temperature substrates
- Adhere well to most materials
- Robust coating

# Radiation Hardness



Multi-layer nitride / oxide coating exposed to  $\sim 10^{15}$  protons/cc flux  
at 20 keV, 50 keV, 100 keV and 300 keV

# Advantages of Sputter Deposition

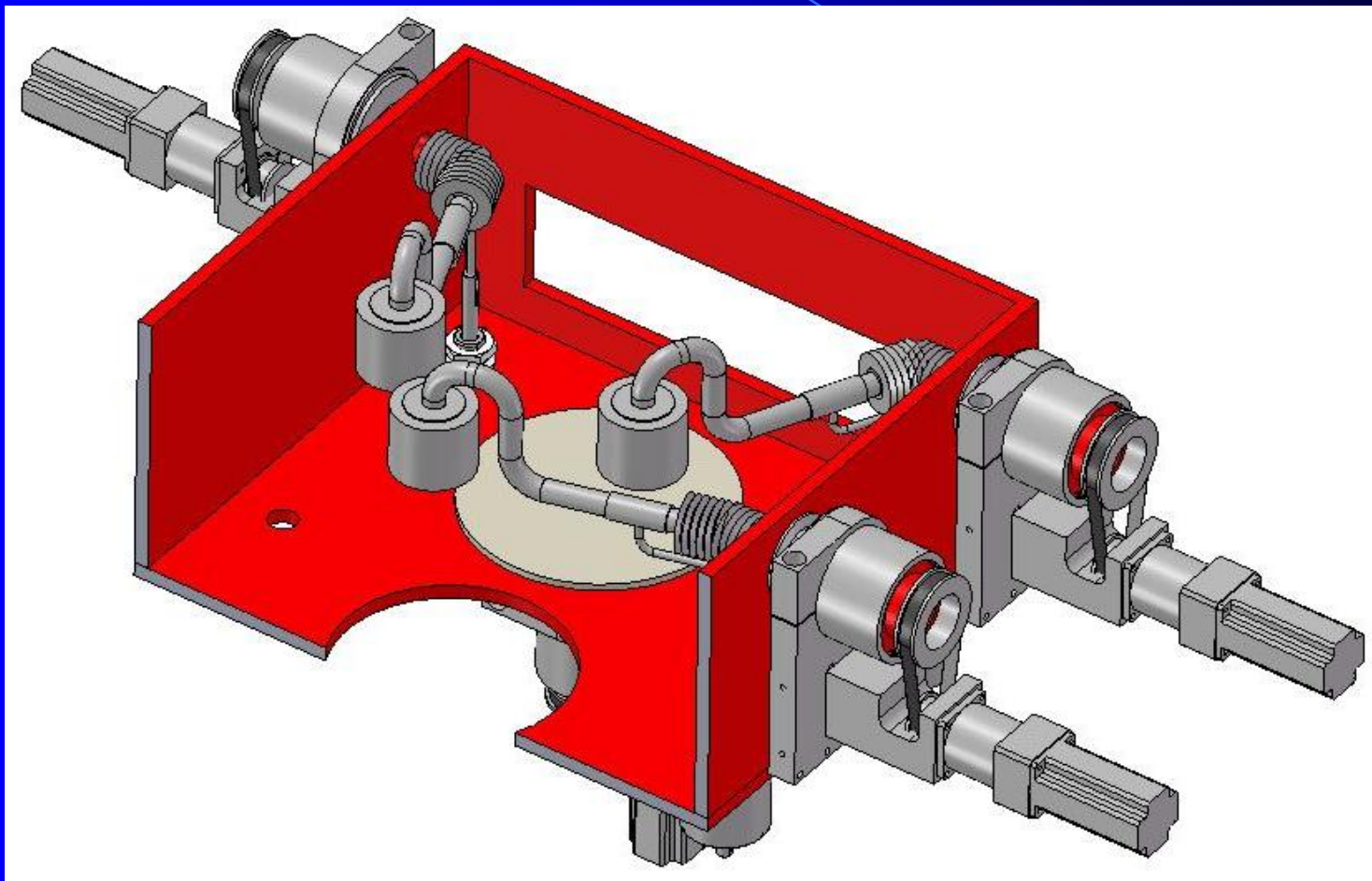
- Able to deposit optical quality films
- Reactive growth of nitrides and oxides results in relatively fast deposition rates
- Sputter process results in higher density, better adhesion coatings compared to e-beam deposition
  - Bias sample if increased density desired
- Deposit on cooled substrates
- Large established infrastructure
- Relatively inexpensive process that can handle large substrates

# CVC 601 Sputter Deposition System





# New Deposition System



# Amorphous Nitride / Oxide Growth

- Coating materials: AlN, ZrO<sub>2</sub>, and SiO<sub>2</sub>
- All materials grown using reactive sputtering
  - Solid target (Al, Zr, Si)
- RF power between 200 and 500 W RF
- Growth rates ~0.2-0.5 microns / hr
- Thickness measured using optical methods (Filmetrics F20) and profilometry (Dektak)
- No delamination noted after thermal cycling (-55 C to 75 C)

# Growth Rate and Adhesion Strength

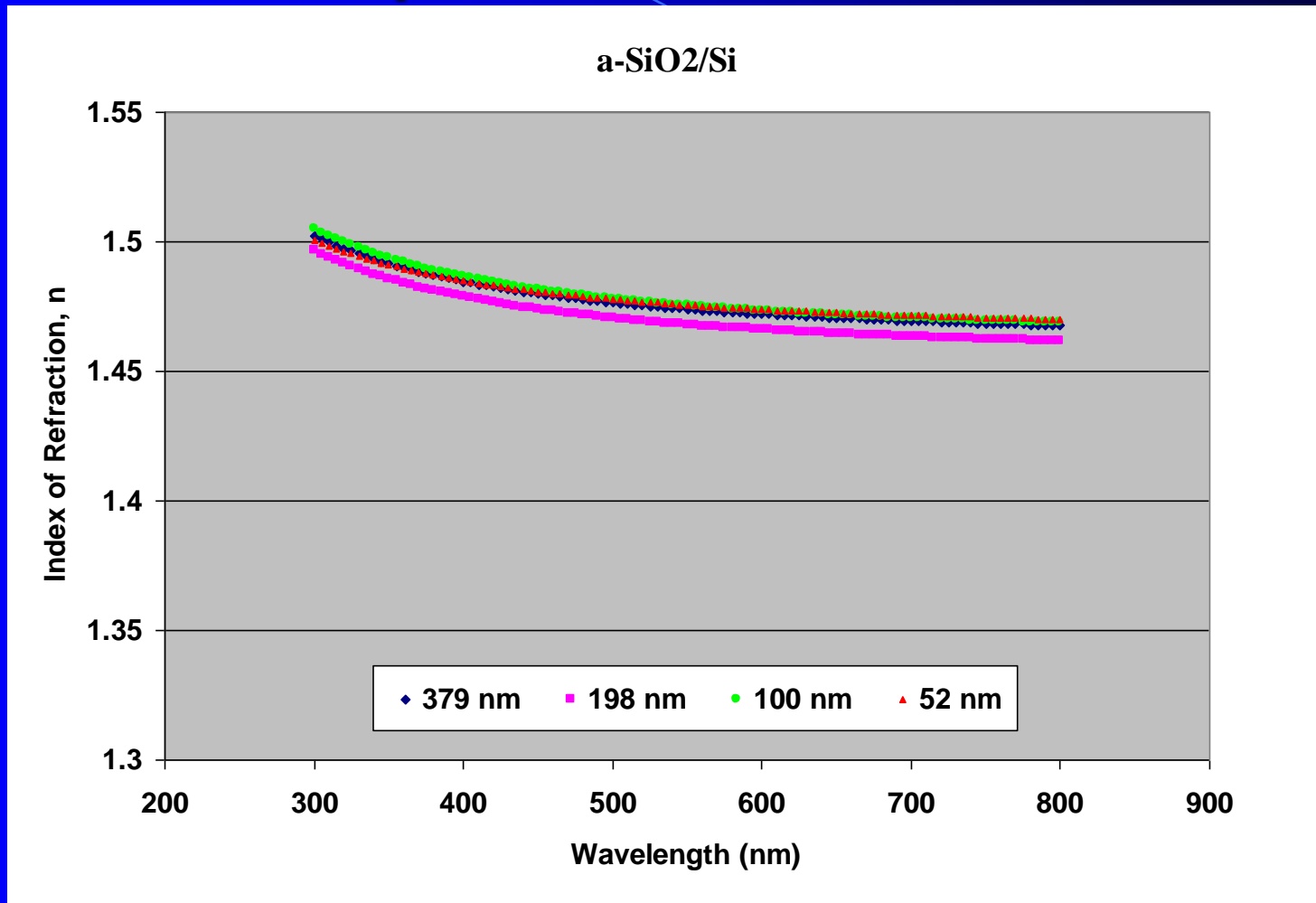
Growth rate of  $\text{SiO}_2$ ,  $\text{AlN}$ , and  $\text{ZrO}_2$  at 400 W RF power.

Material	Growth Rate
$\text{SiO}_2$	6.7 nm/min
$\text{AlN}$	1.9 nm/min
$\text{ZrO}_2$	2.0 nm/min

Adhesion strength to PMMA

	$\text{AlN}$	$\text{SiO}_2$	$\text{ZrO}_2$
Max Adhesion Force (Kg)	4.7	3.0	1.0
Max Adhesion Strength ( $\text{Kg}/\text{cm}^2$ )	83	52	18

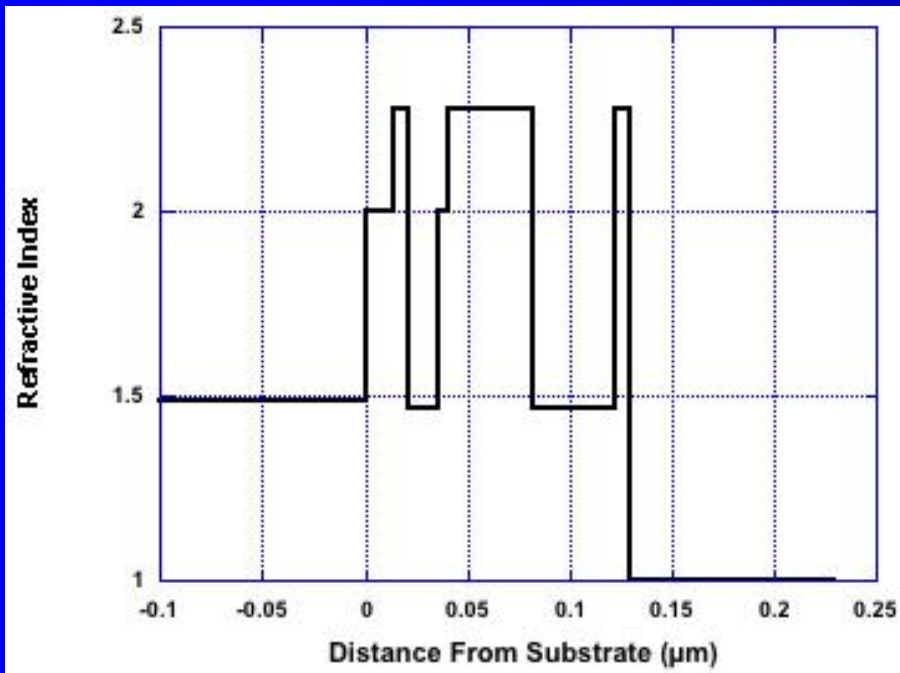
# Dispersion Curves



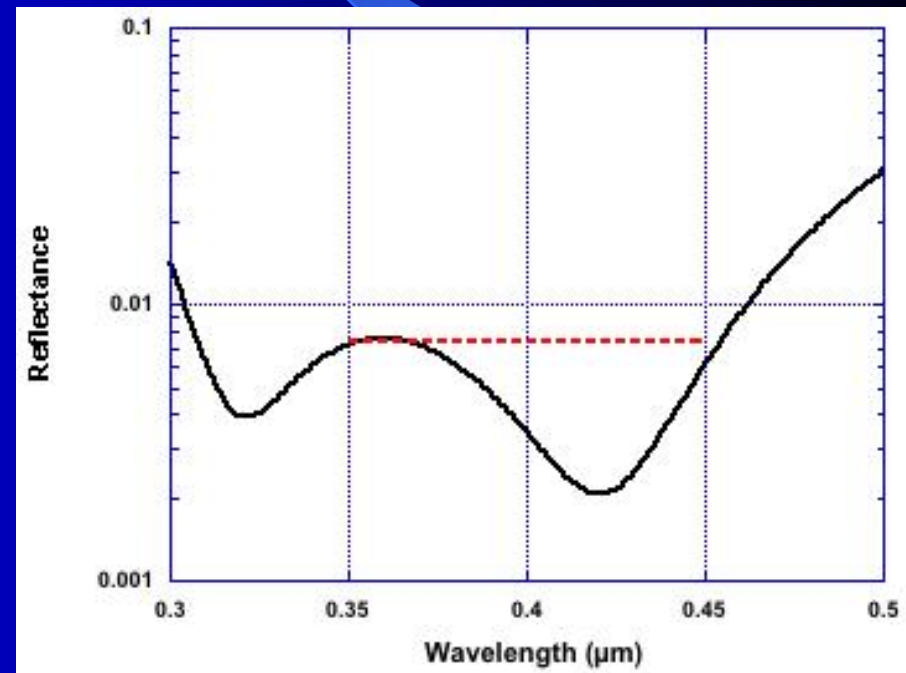
- At 500 nm: AlN ( $n=1.94$ ), ZrO<sub>2</sub> ( $n=2.1$ ), SiO<sub>2</sub> ( $n=1.48$ )
- $k < 0.01$  (transparent materials) over studied range

# Anti-Reflective Coating Model

$\text{SiO}_2$ , AlN, and  $\text{ZrO}_2$

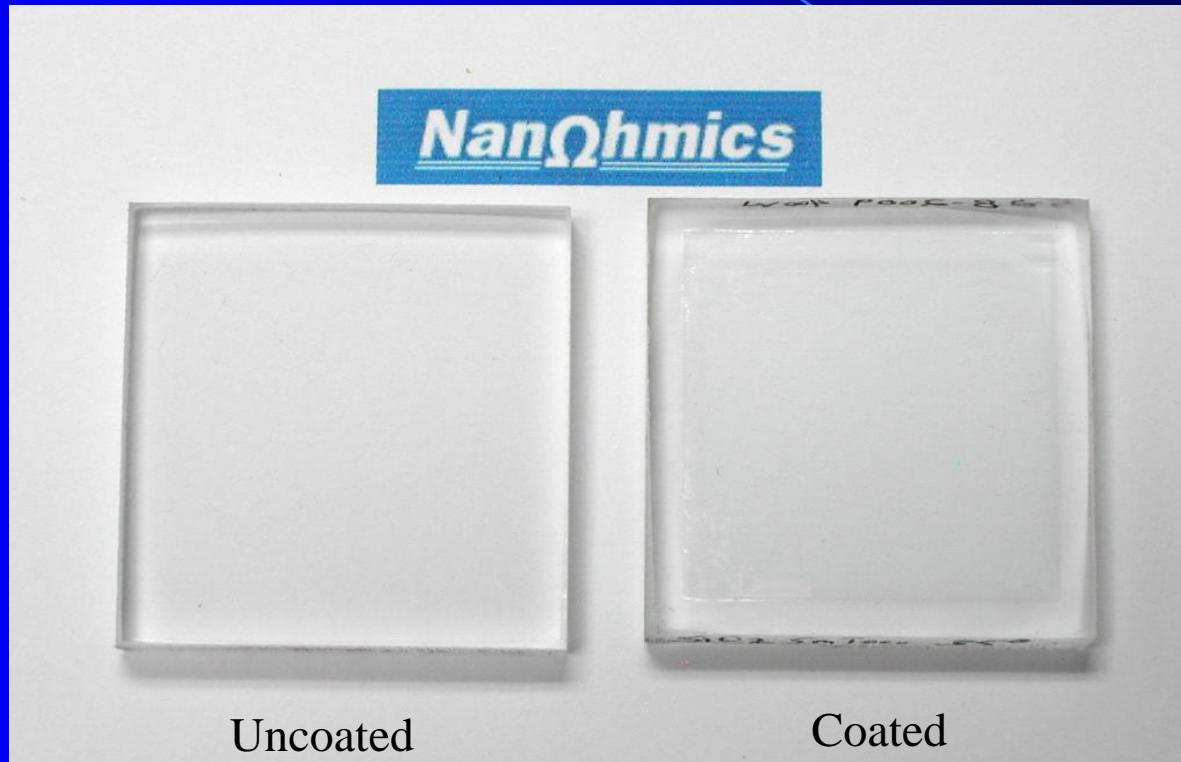


Prescription



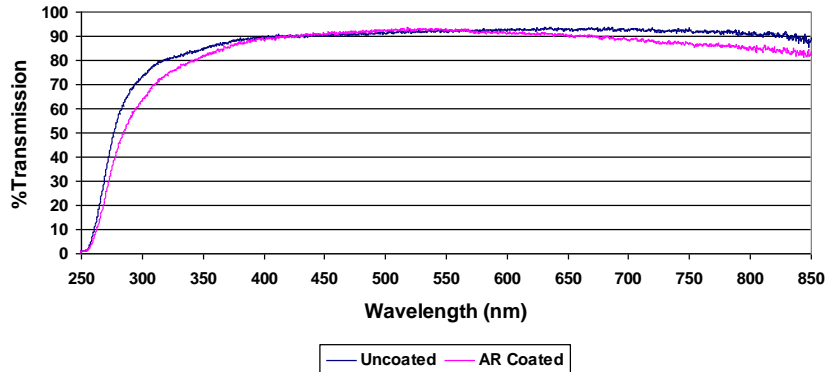
Anticipated Spectrum

# AR Coated UVT PMMA

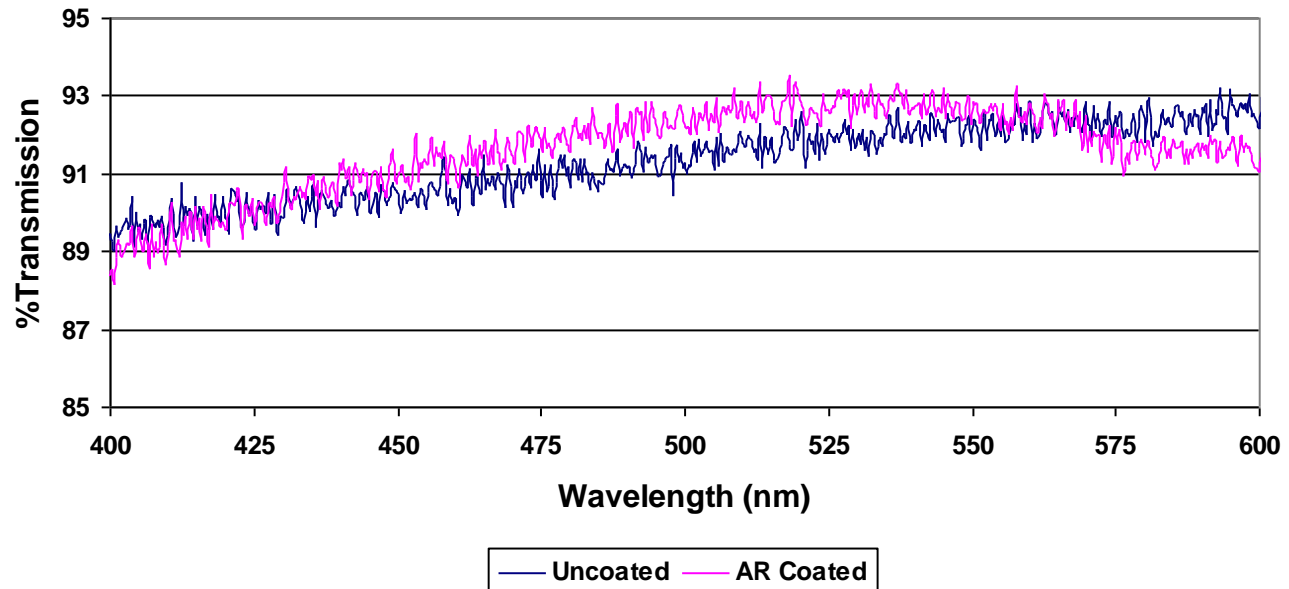


# AR Coated UVT PMMA

AR Coated UVT-PMMA

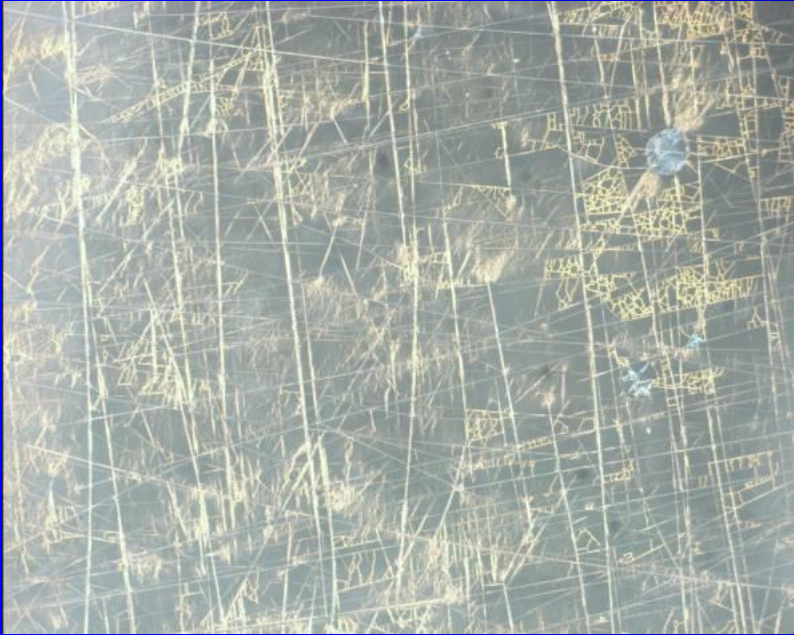


AR Coated UVT-PMMA





# Stress



AlN at 600 W

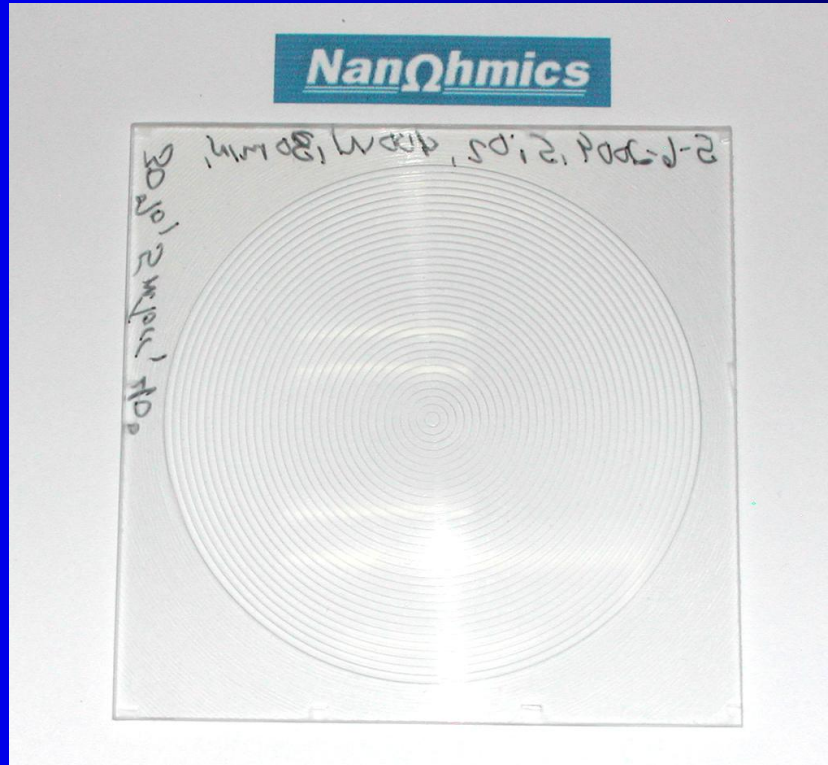


AlN at 200 W



## Current Status / Results

- Measured  $n$  and  $k$  for amorphous materials
- Developed method for reducing stress in the films
- Designed new deposition system to be used for Fresnel lens coating
- Initial AR coatings look promising



# Future Work

- Improve models with new data
- Qualify new deposition tool
  - Deposition parameters
  - Coating uniformity
  - Stress reduction
- Deposition on Fresnel lenses